PRO ECP 15

M E M O R A N D U M

TO: Gary W. Goforth, Chief Consulting Engineer, EES, ECP
Tracey Piccone, Senior Environmental Engineer, EES, ECP

FROM: Lehar M. Brion, Lead Engineer, HSM, WSD
Alaa Ali, Senior Engineer, HSM, WSD

THROUGH: Jayantha T.B. Obeysekera, Department Director, HSM, WSD
Luis G. Cadavid, Senior Supervising Engineer, HSM, WSD

DATE: April 15, 2002

SUBJECT: ECP Base Simulation and 2050 with Project Simulation Using the South Florida Water Management Model

Introduction

This memorandum documents the most recent update to the regional hydrologic model simulations related to the Everglades Construction Project (ECP). In a memorandum sent last Sept. 27, 2001 from R. Bushey to K. Ammon & J. Obeysekera, two regional simulations using the South Florida Water Management Model (SFWMM) were requested to establish a revised baseline simulation and a future case simulation. These simulations were required for the Basin-Specific Feasibility Studies (BSFS) Project. A series of meetings between ECP and Hydrologic Systems Modeling (HSM) Division staff were conducted in October 2001 to: (1) develop operating rules and ascertain flow structure capacities for the integrated Stormwater Treatment Areas (STAs) and reservoirs; (2) establish modeling assumptions consistent with those established for CERP's Water Preserve Area (WPA) modeling; and (3) set deadlines in accordance with ECP staff's project schedule. The modeling simulations were performed using the South Florida Water Management Model and were completed on Dec. 4, 2001. Although HSM and ECP staff have been working together to analyze the modeling results since January 2002, this memorandum formally summarizes the differences in the model output among the original ECP base simulation (BASERR1), the latest revision to the base simulation (BASERR2R) and the ECP future base with CERP projects simulation (2050wPROJ). Differences among the three simulations will be explained but emphasis will be given to differences between the latter two simulations: BASERR2R and 2050wPROJ.

Description of Model Simulations

The original base simulation using the SFWMM (BASERR1) was the result of a series of model updates based on the design specifications of the STAs. It documented and was compared to its precursor (model simulation ALT1) in a memorandum sent to ECP on Dec. 2001 (Brion, 2001). The latest version of the ECP base run, referred to as BASERR2R, is one of the two regional models simulations completed last Dec. 2001 by HSM for ECP. BASERR2R is essentially the same as BASERR1 with two exceptions. First, for consistency across District programs, the new C-139 basin flow data set as defined in the C-139 rulemaking process was incorporated into BASERR2R (Bushey, 2001). The new time series has annual, wet season and dry season average flows equal to 135 kaf/yr, 104 kaf/yr and 31 kaf/yr, respectively. The C-139 basin runoff time series used in BASERR1 is not significantly different from the new time series in terms of annual, wet season and dry season averages. For BASERR1, they are equal to 131 kaf/yr, 112 kaf/yr and 19 kaf/yr, respectively. Second, C-139 basin runoff distribution going into

STA-5 and STA-6 was modified from fixed percentages (65% into STA-5 and 35% into STA-6), to one that is dependent on STA-5 water level. Inflows into STA-5 would occur when the water level in the STA is below 16.75 ft NGVD. Since a substantial gradient in the topography within STA-5 exists, it was decided to break the 2-grid cell representation for this STA into eastern and western compartments (STA-5E and STA-5W). Land surface elevation data for the two grid cells were also updated from simulation BASERR1 (12.0 ft NGVD for both grid cells) to BASERR2R and 2050wPROJ simulations (11.75 ft NGVD and 11.0 ft NGVD). Although the model makes a distinction between these compartments, STA-5 is still operated as a single STA in the model. Transfer of water between STA-5W and STA-5E was accomplished by means of interior weirs (Goforth, 2001). Thus, inflows into STA-5 in BASERR1 can be compared against inflows into STA-5W in BASERR2R while outflows from STA-5 in BASERR1 can be compared against outflows from STA-5E in BASERR2R. STA-6 receives that portion of C-139 runoff that bypasses STA-5W in the BASERR2R simulation. For consistency with BASERR1, BASERR2R was simulated using version 3.8 of SFWMM.

The second simulation completed last December, referred to as 2050wPROJ, is built upon BASERR2R. It includes all CERP components as modeled in the Water Preserve Area – Tentative Selective Plan (WPA-TSP) <http://www.sfwmd.gov/org/pld/restudy/hpm/index.html> which, in turn, was an updated simulation of the recommended plan during the Central and Southern Florida Project Review Study (RESTUDY) as reflected in the regional simulation ALTD13R (USACE, 1999a). 2050wPROJ also incorporates the design specifications for the EAA reservoirs as defined in the CERP/Restudy Final Feasibility Report and PEIS (USACE, 1999a) and the revised footprint shown in the EAA Storage Reservoirs Project PMP (USACE, 2002). The EAA reservoirs are intended to work in conjunction with the Stormwater Treatment Areas. From a local perspective, they are designed to meet supplemental agricultural irrigation demands and increase flood protection within the EAA. From a regional perspective, the EAA reservoirs are expected to reduce damaging flood releases from the EAA and Lake Okeechobee (LOK) to the Water Conservation Areas (WCAs) and estuaries, respectively. Actual operation of these reservoirs is expected to commence in 2010.

Since substantial input data changes were required when proceeding from the BASERR2R simulation to 2050wPROJ simulation, it was decided that the latest version of the model, V4.4, be used for simulating the latter scenario. A list of model enhancements was documented in an internal memorandum which traces the evolution of the model from V3.7 to V4.4 (Santee, 2001). A more detailed description of the proposed EAA reservoirs is given in the next section.

EAA Reservoirs as Simulated in 2050wPROJ

The configuration of the proposed EAA reservoirs as modeled in 2050wPROJ is a revision of the configuration used in WPA-TSP and ALTD13R (USACE, 1999a). For 2050wPROJ, the total EAA reservoir area is 59,901 acres with a total storage capacity of 355,805 acre-feet. A maximum depth of approximately six feet is imposed for all reservoirs. They are basically divided into three geographical areas within the EAA: central (compartments A1 and A2), eastern (compartment B) and western (compartment C) reservoirs. The central reservoir is divided into a primary reservoir (compartment A1) and a surge tank (compartment A2). Runoff from the Miami Canal and North New River Canal (NNRC) basins will be pumped into compartment A1. Regulatory discharges from Lake Okeechobee discharge into compartments A2, B and C. In addition, emergency overflows from A1 and A2 discharge into A2 and B, respectively. Compartments A2 and B are also referred to as the northern and southern surge tanks, respectively. Compartment A1 releases will be used to meet Everglades Agricultural Area (EAA) irrigation demands only. Compartment A2 discharges will be used to meet environmental demands as a priority and can be used to supply a portion of agricultural demands in times when no environmental demands exist. Compartments B and C discharges will be used to meet environmental demands only. Figure 1 is a schematic showing the model grid cells used to represent the STAs and the proposed EAA reservoirs in the 2050wPROJ simulation. The general characteristics of the reservoirs are given in Table 1.

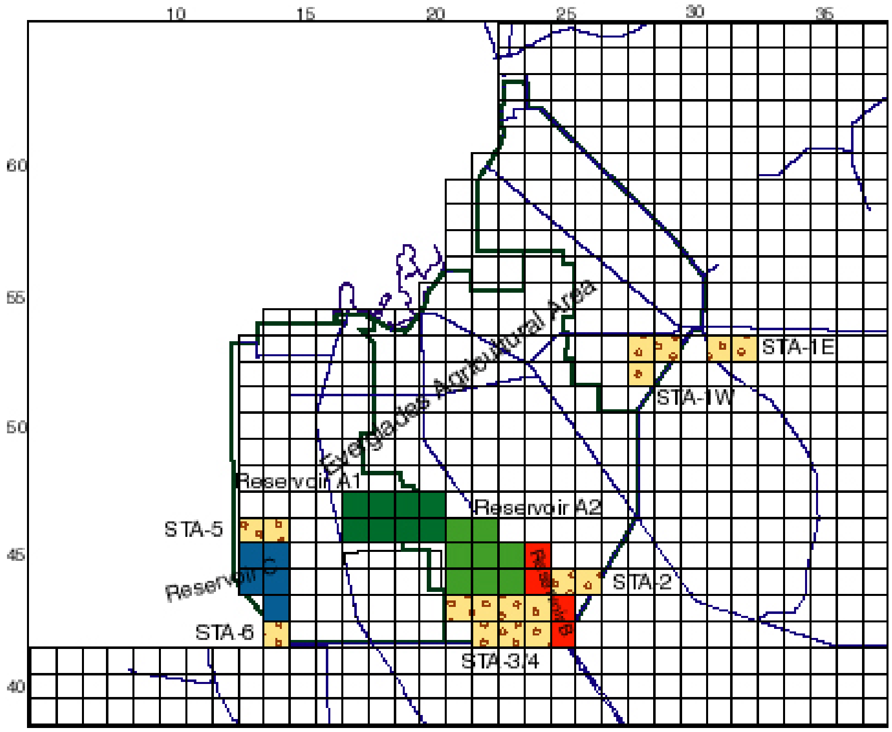

Figure 1. SFWMM Grid Cells Used to Simulate Stormwater Treatment Areas and Proposed Everglades Agricultural Area Reservoirs

Table 1. General Description of Proposed Reservoirs in the Everglades Agricultural Area

EAA Storage Reservoir	Model Designation (Variable Name)	Model Area*, acres	Source of Inflow	Outflow Destination
A or Central	A1 (EAARA1)	20,000	Miami & NNRC runoff	Supplemental deliveries to EAA Miami & NNRC basins; overflow to A2
	A2 (EAARA2)	21,495	Excess water from Lake Okeechobee	Environmental demands via STA-3/4; supplemental deliveries to EAA Miami & NNRC basins; overflow to B
B or Eastern	B (EAARSB)	9,522	Excess water from Lake Okeechobee	Environmental demands via STA-3/4
C or Western	C (EAARSC)	8,884	Excess water from Lake Okeechobee	Environmental demands via STA-6

*: Maximum depth for each reservoir is 6 ft.

Compartment A1 of the central reservoir, referred to as EAARA1 in the SFWMM, is a 20,000 acre reservoir that receives excess runoff from the Miami and North New River Canal Basins in the EAA. EAARA1 reservoir encompasses eight grid cells in the model domain (rows 46-47, columns 17-20) with an average land surface elevation of 12.08 ft NGVD. The maximum stage allowed for structural inflow is 18 ft NGVD, which results in a volumetric capacity of 118,400 ac-ft. A 2,700 cfs inflow pump is used to remove runoff from the Miami Canal Basin and a 2,300 cfs inflow pump is used to remove runoff from the North New River Canal Basin. The primary outflow structures to the Miami and North New River-Hillsboro Canal Basins, for irrigation supply, are a 3,000 cfs @ 6' head gravity structure and a 4,400 cfs @ 6' head gravity structure, respectively. An overflow weir releases water from the EAARA1 reservoir to compartment A2, referred to as EAARA2 in the SFWMM, when the stage in the EAARA1 reservoir reaches 17.7 ft NGVD (or 0.3' below the maximum stage of 18.0') and storage capacity is available in the EAARA2 reservoir.

Compartments A2, B and C are referred to as reservoirs EAARA2, EAARSB and EAARSC in the model, respectively. With footprints of 21,495 acres; 9,522 acres and 8,884 acres, respectively, they receive excess water from Lake Okeechobee (LOK). In WPA-TSP simulation, LOK operates under a modified Run 25 regulation schedule (USACE, 1999a) with added forecasting features to take advantage of the additional storage facilities (i.e. North Storage, Lake Okeechobee ASR, EAA Reservoirs). In the 2050wPROJ simulation, LOK operates under a modified WSE regulation schedule (USACE, 2000) whose forecasting features were extended to take advantage of the additional storage facilities. Releases from Lake Okeechobee to the EAARA2 reservoir occur when the 3-month forecast predicts the LOK stage will be above the reservoir injection line, while discharges from LOK to the EAARSC reservoir occur when the current state of the LOK stage is above the reservoir injection line. The reservoir injection line is based on LOK stage at 14.75 ft NGVD on January 1st, linearly decreases to 14.35' on May 31st, linearly increases back to 14.75' on October 1st, and remains constant at 14.75' through December 31st. Canal conveyance capacities to the reservoirs are increased by 200 percent from current levels for the Miami and North New River Canals in order to direct LOK regulatory releases to the reservoirs. Environmental water supply deliveries to Water Conservation Area 3A (WCA-3A), via STA-3/4, occur when downstream stage at gage WC3NE in WCA-3A fall below their specified target trigger, and via STA-6 when downstream stages at gage NWC3A in WCA-3A fall below their specified target trigger. Environmental water supply demands are met by the EAARSB reservoir if enough storage exists; if not, then the EAARA2 reservoir is also used to meet the unmet demands. The BASERR1 and BASERR2R simulations also use the WSE regulation schedule for Lake Okeechobee.

The EAARA2 reservoir encompasses eight grid cells in the model domain (rows 44-46, columns 21-22; rows 44-45, column 23) with an average land surface elevation of 11.40 ft NGVD. The maximum stage allowed for structural inflow is 17.5 ft NGVD, which results in a volumetric capacity of 131,120 ac-ft. A 4,500 cfs inflow pump is used to remove excess water from LOK through the Miami Canal and a 3,000 cfs inflow pump is used to remove excess water from LOK through the North New River Canal. The North New River Canal route is used only if the Miami Canal route cannot accommodate the total of the regulatory releases for one particular day. The environmental water supply outflow structures are a 3,800 cfs @ 6.5' head gravity structure and a 750 cfs pump. The pump is used when EAARA2 reservoir stages fall below land surface elevation and operates down to two feet below land surface elevation. The outflow structures to the Miami and North New River-Hillsboro canals, for irrigation supply, are 1,800 cfs @ 5.5' head gravity structure, and 1,700 cfs @ 5' head gravity structure, respectively, for each basin. An overflow weir releases water from the EAARA2 reservoir to the EAARSB reservoir when the stage in the EAARA2 reservoir reaches 17.25 ft NGVD (or 0.25' below the maximum stage of 17.5 ft NGVD) and capacity exists in the EAARSB reservoir to store additional water.

The EAARSB reservoir encompasses four grid cells in the model domain (rows 44-45, column 24; rows 42-43, column 25) with an average land surface elevation of 10.60 ft NGVD. The maximum stage allowed for structural inflow is 16.5 ft NGVD, which results in a volumetric capacity of 56,180 ac-ft. A 3,000 cfs inflow pump is used to remove excess water from LOK through the North New River Canal. The environmental water supply outflow structures are a 3,500 cfs @ 5.5' head gravity structure and a 750 cfs pump. The pump is used when EAARSB reservoir stages fall below land surface elevation and operates down to two feet below land surface elevation.

The EAARSC reservoir encompasses five grid cells in the model domain (rows 43-45, column 14; rows 44-45, column 13) with an average land surface elevation of 13.86 ft NGVD. The maximum stage allowed for the structural inflow is 19.5 ft NGVD, which results in a volumetric capacity of 50,106 ac-ft. A 1,000 cfs inflow pump is used to remove excess water from LOK through the Miami Canal. The environmental water supply outflow structures are a 1,000 cfs @ 6.3' head gravity structure and a 700 cfs pump. The pump is used when EAARSC reservoir stages fall below land surface elevation and operates down to two feet below land surface elevation. Table 2 summarizes the structure information for the proposed Everglades Agricultural Area Reservoirs as simulated in the SFWMM.

Table 2. Structure Information for the Proposed Everglades Agricultural Area Reservoirs as Represented in the 205wPROJ SFWMM (V4.4) Simulation

	Source/Destination of Water	**Structure type**	**Crest Elev., ft NGVD**	**Design Capacity*, cfs**
EAARA1 Reservoir	area: 20,000 acres; average land surface elevation: 12.08 ft NGVD; maximum stage: 18.0 ft NGVD			
Structural Inflows				
CPAIN1	Miami Canal Basin	Pump	N/A	2700
CPAIN2	North New River Basin	Pump	N/A	2300
Structural Outflows				
WCS1	Miami Canal Basin	Gravity	12	$1225(\Delta h)^{.5}$ 3,000 cfs @ 6'
WCS2	NNR / Hillsboro Canal Basin	Gravity	12	$1800(\Delta h)^{.5}$ 4,400 cfs @ 6'
EARSAO	EAARA2 reservoir	Gravity	17.7	$4000(\Delta h)^{.5}$
EAARA2 Reservoir	area: 21,495 acres; average land surface elevation: 11.40 ft NGVD; maximum stage: 17.5 ft NGVD			
Structural Inflows				
EARSAO	EAARA1 reservoir	Gravity	17.7	$4000(\Delta h)^{.5}$
LKRSM1	Lake Okeechobee via Miami Canal	Pump	N/A	4500
LKRSN1	Lake Okeechobee via NNR Canal	Pump	N/A	3000
Structural Outflows				
WCS4N	STA-3/4	Gravity	11	$1500(\Delta h)^{.5}$ 3,800 cfs @ 6.5'
WSTMB	Miami Canal Basin	Gravity	12	$750(\Delta h)^{.5}$ 1,800 cfs @ 5.5'
WSTNRH	NNR Canal Basin	Gravity	12.5	$750(\Delta h)^{.5}$ 1,700 cfs @ 5'
EVBLSN	STA-3/4	Pump	N/A	750
EARA2O	EAARSB reservoir	Gravity	17.25	$3000(\Delta h)^{1.5}$
EAARSB Reservoir	area: 9,522 acres; average land surface elevation: 10.60 ft NGVD; maximum stage: 16.5 ft NGVD			
Structural Inflows				
EARA2O	EAARA2 reservoir	Gravity	17.25	$3000(\Delta h)^{1.5}$
LKRSN2	Lake Okeechobee via NNR Canal	Pump	N/A	3000
Structural Outflows				
WCS4S	STA-3/4	Gravity	11	$1500(\Delta h)^{.5}$ 3,500 cfs @ 5.5'
EVBLSS	STA-3/4	Pump	N/A	750
EAARSC Reservoir	area: 8,884 acres; average land surface elevation: 13.86 ft NGVD; maximum stage: 19.5 ft NGVD			
Structural Inflows				
LKRSM2	Lake Okeechobee via Miami Canal	Pump	N/A	1000
Structural Outflows				
WCS4W	STA-6	Gravity	13.2	$400(\Delta h)^{.5}$ 1,000 cfs @ 6.3'
EVBLSW	STA-6	Pump	N/A	700

* : Design capacities are rounded off to the nearest 100 cfs.

Selected Results and Discussion

As in past SFWMM simulations, the model output will be used to perform water quality assessment in the receiving basins as defined under the Basin-Specific Feasibility Study and the Everglades Stormwater Program. Differences in the simulated flows between the previous base simulation (BASERR1), revised base simulation (BASERR2R) and future base with project simulation (2050wPROJ) are identified next. Table 3 shows simulated inflows and outflows associated with the six STAs and simulated outflows from six selected non-ECP basins (Everglades tributary basins under the ESP or Everglades Stormwater Program). The table contains average, minimum and maximum annual discharges in 1,000 acre-feet for the 1965-1995 period-of-record. A brief explanation of differences in these quantities across model simulations is also given.

Table 3. Summary of Simulated Flows from the BASERR1, BASERR2R and 2050WPROJ Simulations Using the South Florida Water Management Model

STA or Basin		Inflows, kaf/yr			Outflows, kaf/yr			Associated Model Variable Names
		Average	Minimum	Maximum	Average	Minimum	Maximum	
STA-1E	BASERR1	133.3	57.3	253.3	136.5	52.6	268.9	ST1EI1, S319, S1324P, WSST1E; ST1EQ1, S319WS, G311
	BASERR2R	133.3	56.9	253.3	136.5	52.1	268.9	
	2050WPROJ	204.4	86.4	373.8	202.4	77.5	375.1	
STA-1W	BASERR1	160.3	71.5	235.4	161.9	71.1	247.4	ST1WI1, WSST1W; ST1WQ1
	BASERR2R	160.2	71.1	235.3	161.8	70.7	247.4	
	2050WPROJ	138.4	62.8	239.7	139.7	64.0	246.8	
STA-2	BASERR1	233.4	102.1	383.0	229.3	94.5	393.1	298ST2, RFTST2, WSSTA2, FLIMPH, HLSBRG; ST2OT1
	BASERR2R	233.4	101.9	383.0	229.2	94.4	393.1	
	2050WPROJ	208.4	110.4	325.4	205.5	104.5	337.6	
STA-3/4	BASERR1	657.7	243.1	1250.1	637.9	218.9	1244.5	MIAST3, NNRST3, FLIMPM, FLIMPN, 354RG, NNRCRG, 298ST3, S236SO, G136SO, WSSTA3, EVBLSN, WCS4N, EVBLSS, WCS4S; ST3TL4, ST3NEA, ST3TNW, ST3TS8, ST3TS7
	BASERR2R	656.6	234.2	1241.8	636.9	210.1	1234.0	
	2050WPROJ	628.4	145.8	1687.6	615.9	132.4	1707.2	
STA-5	BASERR1	86.0	36.1	203.8	83.7	29.8	212.9	G88, G89, G155, WSST5E, WSSTA5, STA5WO, ST5REX,STA5IQ; ST5OT1, ST5TCL, ST5TMR
STA-5W	BASERR2R	132.1	24.7	259.2	130.7	22.7	261.8	
	2050WPROJ	147.0	24.3	264.0	145.4	22.6	267.1	
STA-5E	BASERR2R	130.8	22.7	261.8	129.4	21.4	265.2	
	2050WPROJ	145.4	22.6	267.1	144.0	21.2	270.2	
STA-6	BASERR1	80.6	38.8	160.7	74.9	32.5	155.6	G88, G89, G155, WCS4W, EVBLSW, WSSTA6, U1TL28, SUGRF, ST6REX, ST5REX, SUGREX; ST6OT1
	BASERR2R	37.8	13.0	95.8	33.0	6.4	91.1	
	2050WPROJ	60.6	7.9	137.9	57.3	1.1	131.6	
ACME Basin B	BASERR1	N/A	N/A	N/A	31.5	9.9	49.8	ACMERF, ACBCA1, ACMBLD
	BASERR2R				31.5	9.9	49.8	
	2050WPROJ				22.4	10.2	35.2	
NSID	BASERR1	N/A	N/A	N/A	6.2	0.3	15.6	NSIMP2, NSIMP3
	BASERR2R				6.2	0.3	15.6	
	2050WPROJ				N/A	N/A	N/A	
NNRC	BASERR1	N/A	N/A	N/A	1.8	0.0	6.3	G123
	BASERR2R				1.8	0.0	6.3	
	2050WPROJ				N/A	N/A	N/A	

STA or Basin		Inflows, kaf/yr			Outflows, kaf/yr			Associated Model Variable Names
		Average	Minimum	Maximum	Average	Minimum	Maximum	
C-11W	BASERR1	N/A	N/A	N/A	194.2	117.2	262.8	S9
	BASERR2R				194.3	116.8	262.7	
	2050WPROJ				23.8	9.0	36.8	
L-28	BASERR1	N/A	N/A	N/A	83.8	48.6	130.5	S140A
	BASERR2R				83.9	46.4	134.9	
	2050WPROJ				423.0	158.6	694.3	
Feeder Canal	BASERR1	N/A	N/A	N/A	77.2	11.5	180.8	S190
	BASERR2R				77.2	11.5	180.8	
	2050WPROJ				77.2	11.5	180.8	

Notes: G136SO, G88, G89, G155 and S190 are boundary flows.
N/A = not applicable

<u>STA-1E</u>

- As expected, the two base simulations, BASERR1 and BASERR2R, produced very similar discharge values associated with STA-1E. Total inflow into STA-1E increased from BASERR2R to 2050wPROJ by 71.1 kaf/yr (or +53%) due to an increase in the contribution of C-51W basin runoff into STA-1E via S-319. C-51W basin, in turn, received more runoff in the 2050wPROJ simulation from basins that did not use to contribute runoff in the BASERR2R simulation. This assumption change is consistent with the WPA-TSP simulation. The increased C-51W basin inflow is due to additional runoff primarily from the M-1 basin and Lake Worth Drainage District and to a very limited extent, the ACME Basin B.
- ST1EQ1, the major outflow for STA-1E, increased by 65.9 kaf/yr (or +48%) as a consequence of increased inflows into STA-1E.

<u>STA-1W</u>

- ST1WI1, the major inflow for STA-1W, remained practically the same for the base simulations. However, it decreased by 21.8 kaf/yr (or -14%) from BASERR2R to 2050wPROJ. The reduction can be explained by a difference in assumptions as far as environmental releases from Lake Okeechobee (LOK) are concerned. In BASERR2R, environmental releases from LOK are made via STA-1W in the form of Best Management Practice (BMP) make-up water. In 2050wPROJ, although rainfall-driven operations are implemented system-wide, a regulation-schedule type of operations was assumed for WCA-1 that precluded environmental deliveries made via STA1W. This assumption is consistent with ALTD13R. Environmental deliveries from the LOK are still made via STA-3/4 and STA-2.
- A corresponding drop in annual average discharge from STA-1W (from 161.9 kaf/yr to 139.7 kaf/yr) can be observed from the BASERR2R to the 2050wPROJ simulation.

<u>STA-2</u>

- Inflows to STA-2 for the base simulations practically remained unchanged. An 11% (25 kaf/yr) drop in inflows occurred from BASERR2R to 2050wPROJ. This decrease is due primarily to a reduction in EAA runoff from the North New River basin that would normally (in BASERR1 and BASERR2R) go to STA-2 but is now captured (in 2050wPROJ) by compartment A1 of the proposed EAA reservoirs.
- A corresponding drop in annual average discharge from STA-2 (from 229.2 kaf/yr to 205.5 kaf/yr) can be observed from the BASERR2R to the 2050wPROJ simulation.

<u>STA-3/4</u>

- Inflows to STA-3/4 for the base simulations practically remained unchanged. A reduction in STA-3/4 inflows occurred from BASERR2R to 2050wPROJ (28.2 kaf/yr or -4%). Although additional inflows from the proposed EAA reservoirs to STA-3/4 existed in the 2050wPROJ simulation (228.1 kaf/yr), the combined reduction in inflows from EAA (Miami and North New River basins) runoff, LOK regulatory discharges and environmental releases (256.3 kaf/yr) made up for the overall decrease in inflows to STA-3/4.

- A corresponding decrease in total outflow from STA-3/4 (636.9 kaf/yr to 615.9 kaf/yr or -3%) occurred from BASERR2R to 2050wPROJ.

<u>STA-5</u>

- A substantial increase in inflows occurred between BASERR1 and BASERR2R (from 86.0 kaf/yr to 132.1 kaf/yr or +54). Inflows into STA-5 in the BASERR1 simulation represents 65% of the runoff generated from C-139 basin (131 kaf/yr). The inflows into STA-5 in the BASERR2R simulation represents almost 98% of the revised runoff generated from C-139 basin (135 kaf/yr). The increase is a consequence in the way C-139 runoff is routed into STA-5, as explained earlier in this memorandum.
- A further increase in inflows into STA-5 (from 132.1 kaf/yr to 147.0 kaf/yr or +11%) occurred from BASERR2R to 2050wPROJ. The increase can be explained by an additional inflow into STA-5 from Lake Okeechobee to meet environmental targets in the Rotenberger Wildlife Management Area. This quantity of water (14.7 kaf/yr) is a flow-through discharge for STA-5W/STA-5E. It was incorporated in the 2050wPROJ simulation to be consistent with the WPA-TSP simulation.
- Increases in discharges out of STA-5 from BASERR1 to BASERR-2R and 2050wPROJ simulations can be explained by increases in inflows to the same STA.

<u>STA-6</u>

- Inflows into STA-6 decreased by 42.8 kaf/yr (or –53%) from BASERR1 to BASERR2R. This trend can be explained by the fact that in the latter simulation, more of C-139 basin runoff discharged into STA-5 and less into STA-6. Whereas 35% of C-139 basin runoff discharged into STA-6 in the BASERR1, only approximately 2% of the same occurred in BASERR2R.
- An increase from 37.8 kaf/yr to 60.6 kaf/yr (or +60%) in total inflow occurred from BASERR2R to 2050wPROJ. The increase is primarily due to the contribution of the proposed (in 2050wPROJ) reservoir C. This reservoir receives excess water from Lake Okeechobee in addition to local rainfall.
- Corresponding decrease (from BASERR1 to BASERR2R) and increase (from BASERR2R to 2050wPROJ) can be observed in the total outflows from STA-6.

<u>ACME Basin B</u>

- No difference in simulated outflows/discharges exists between the BASERR1 and BASERR2R simulations. Due to the proposed ACME reservoir, a reduction in WCA-1 inflow from ACME Basin B runoff (from 31.5 kaf/yr to 22.4 kaf/yr or –29%) was simulated in the model. The ACME Basin B reservoir configuration is still under development as of this writing. At a later date, an updated analysis of its impact may be necessary after a final configuration is determined.

<u>North Springs Improvement District</u>

- As proposed in the WPA-TSP simulation the entire runoff from the North Springs Improvement District (NSID) are to be rerouted into the Hillsboro canal. This assumption explains the total elimination of discharges from NSID into Water Conservation Area 2A and is incorporated in the 2050wPROJ simulation.

<u>North New River Canal Basin</u>

- As part of the North New River Improvements component of the WPA-TSP simulation, G-123 will no longer be used to provide flood protection for the North New River Canal basin. The elimination of this structure makes deliveries into WCA-3 non-existent in the 2050wPROJ simulation.

<u>C-11 West Basin</u>

- The significant decrease in discharges from C-11W basin into WCA-3 via S-9 from the BASERR2R simulation to the 2050wPROJ simulation (170.5 kaf/yr or –88%) is the combined effect of the proposed C-11, C-9 and Lakebelt impoundments as defined in the WPA-TSP simulation. As a side note, the simulated S-9 flows in 2050wPROJ is larger than the simulated values based on the WPA-TSP simulation. The difference can be explained by a modification in one of the assumptions in WPA-TSP where environmental needs for Pond Apple Slough (located on the east end of the C-11W/C-11 canal) are being met from water withdrawn from the C-11W/C-11 canal. The 2050wPROJ simulation assumes that such needs are not to be met, thus making more water available to be pumped out for flood control purposes by S-9 which is located on the west side of the C-11W/C-11 canal.

<u>L-28 Basin</u>

- The significant increase in L-28 basin discharges into WCA-3A via S-140A from BASERR2R to 2050wPROJ (339.1 kaf/yr or +404%) is the combined effect of rain-driven operations as implemented in the WPA-TSP simulation. The combined environmental releases from the Water Management Areas (Holey Land and Rotenberger), STA-6 and STA-3/4 into L-28 borrow canal via L-4 borrow canal contributed to the substantial increase in discharge out of S-140A.

<u>Feeder Canal Basin</u>

- No change in outflows exists among the three simulations compared in this memorandum for the Feeder Canal basin. The same boundary flows (77.2 kaf/yr for the 1965-1995 period) were used in the BASERR1, BASERR2R and 2050wPROJ simulations.

Table 4 is a summary of the annual average discharges (inflows and outflows) for the four reservoir compartments simulated for the 31-year period of record (1965-1995).

Table 4. Simulated Annual Average Inflows and Outflows for the Proposed EAA Reservoirs (1965-1995 Simulation Period)

Reservoir	Total Inflow, 1000 ac-ft/yr	Total Outflow, 1000 ac-ft/yr	Associated Model Variable Names
A1	174.8	159.9	CPAIN1, CPAIN2, WCS1, WCS2, EARSAO
A2	127.8	112.8	EARSAO, LKRSM1, LKRSN1, WCS4N, WSTMB, WSTNRH, EVBLSN, EARA2O
B	154.0	145.9	EARA2O, LKRSN2, WCS4S, EVBLSS
C	50.0	45.3	LKRSM2, WCS4W, EVBLSW

Water Supply Deliveries to the Stormwater Treatment Area

The SFWMM simulations attempt to maintain water depth within each Stormwater Treatment Area at a minimum of 0.5 ft. During times of low EAA runoff, this operational criterion cannot be met. Thus, water supply deliveries from Lake Okeechobee are triggered in the model when simulated water levels fall below 10.5, 14.0, 10.5, 10.0 and 13.5 ft NGVD in STA-1W, STA-1E, STA-2, STA-3/4, and STA-6, respectively. STA-5 was treated as a single compartment with a maintenance level of 12.5 ft NGVD in the BASERR1 simulation. However, in the BASERR2R and 2050wPROJ simulations, STA-5 was treated as two (single grid) compartments with separate maintenance levels equal to 12.75 ft NGVD and 11.5 ft NGVD for the western and eastern compartments, respectively. Table 5 shows a comparison of water supply deliveries to the STAs for SFWMM simulations BASERR1, BASERR2R and 2050wPROJ. The four performance indicators in the table were selected to compare the three model simulations.

The percent of time when the stage in a STA is below maintenance level indicates how often Lake Okeechobee is not able to hydrate an STA to a depth of at least six inches. Most STAs maintained their performance in terms of this indicator except for STA-5 and STA-6 where the most significant changes occurred. STA-5 showed a significant decrease (an improvement) in percentages from the BASERR1 to the BASERR2R simulations. STA-6 showed the opposite trend for the same two simulations. These trends were primarily due to the change in assumptions as far as redistribution of C-139 runoff into both STAs as mentioned earlier. 2050wPROJ kept water depths in STA-5 above its maintenance level all the time while STA-6 was maintained at a level slightly better than the BASERR1 simulation. These improvements are due to rain-driven operations as incorporated in 2050wPROJ.

When stages in the STAs are not maintained, the average deviation in depth below the maintenance levels is another indicator of how effectively Lake Okeechobee meets the water supply needs of the STAs. The trends associated with this performance indicators with respect to STA-5 and STA-6 are similar to those in the previous performance indicator. Improvements in the 2050wPROJ simulation for STA-3/4 can be attributed to better timing of inflows from reservoirs A2 and B albeit slight reduction in total inflows as compared with BASERR1 and BASERR2R simulations.

The total demand-not-met for the 31-year period of simulation is an estimate of the volume of water necessary to keep stages in the STAs at least at their maintenance levels all the time. Total demand-not-met is the sum of all stage level drops from one day to the next when the next day stage is below the maintenance level (Brion, 2001). Overall reductions in total demand-not-met can be observed for all STAs. The reduction in the estimated demand-not-met for STA-1W may be attributed to a decrease in groundwater outflow (seepage) from the base simulations to the 2050wPROJ simulation. Reduction of losses in terms of groundwater outflow slows down the natural recession of water levels in the STA that would, in turn, require less water from LOK to keep depths of six inches within the STA. In particular, seepage from STA-1W to the EAA is reduced due to overall EAA water levels being maintained better in the 2050wPROJ simulation compared to both the BASERR1 and BASERR2R simulations. On the other hand, the reduction in demand-not-met for STA-1E can be attributed to the additional inflow it received from C-51W basin when 2050wPROJ is compared against the other base simulations. The performance of STAs –2, -3/4, -5 and -6 improved in this category primarily due to the rain-driven operations as incorporated in 2050wPROJ. STA-2 is a special case because even though the total inflows into it decreased from the base simulations to 2050wPROJ (Table 3), the timing of environmental releases from Lake Okeechobee to the Everglades in conjunction with rain-driven operations afforded the opportunity for less explicit deliveries to STA-2. This is evident in drought conditions such as the Nov. 1970- May 1971 dry season.

The last performance indicator in Table 5 is the amount of water supply deliveries from Lake Okeechobee to the STAs. Reductions in average Lake Okeechobee water supply deliveries were achieved for practically all STAs from the base simulation to 2050wPROJ simulation. In fact, the latter simulation indicated that water supply deliveries to STA-5 would no longer be required.

Table 5. Performance Indicators for STA Water Supply (1965-1995 Simulation Period)

STA (maintenance level)	Performance Indicator	BASERR1	BASERR2R	2050wPROJ
STA-1W (10.5 ft)	Percent of time stage below maintenance level (%)	0.6	0.7	0.6
	Average depth when below maintenance level (ft)	0.06	0.05	0.03
	Estimated 31-year total demand-not-met (1000 acre-ft)	6.9	6.8	3.3
	Average Lake Okeechobee water supply delivery to keep maintenance level (1000 acre-ft/yr)	0.294	0.294	0.122
STA-1E (14.0 ft)	Percent of time stage below maintenance level (%)	0.5	0.3	0.5
	Average depth when below maintenance level (ft)	0.17	0.20	0.17
	Estimated 31-year total demand-not-met (1000 acre-ft)	9.7	9.0	1.3
	Average Lake Okeechobee water supply delivery to keep maintenance level (1000 acre-ft/yr)	0.631	0.607	0.226
STA-2 (10.5 ft)	Percent of time stage below maintenance level (%)	0.7	0.7	0.2
	Average depth when below maintenance level (ft)	0.04	0.04	0.05
	Estimated 31-year total demand-not-met (1000 acre-ft)	6.2	6.2	1.4
	Average Lake Okeechobee water supply delivery to keep maintenance level (1000 acre-ft/yr)	0.256	0.255	0.035
STA-3/4 (10.0 ft)	Percent of time stage below maintenance level (%)	0.1	0.1	0.0
	Average depth when below maintenance level (ft)	0.16	0.16	0.03
	Estimated 31-year total demand-not-met (1000 acre-ft)	9.1	9.1	0.8
	Average Lake Okeechobee water supply delivery to keep maintenance level (1000 acre-ft/yr)	0.547	0.547	0.042

STA (mainte-nance level)	Performance Indicator	BASERR1	BASERR2R	2050wPROJ
STA-5 (12.5 ft for BASERR1 else, 13.25 / 12.0 ft)	Percent of time stage below maintenance level (%)	5.0	0.2+	0.0+
	Average depth when below maintenance level (ft)	0.14	0.33*	Not applicable
	Estimated 31-year total demand-not-met (1000 acre-ft)	14.1	2.3#	0.0#
	Average Lake Okeechobee water supply delivery to keep maintenance level (1000 acre-ft/yr)	0.756	0.154	0.000
STA-6 (13.5 ft)	Percent of time stage below maintenance level (%)	7.5	11.8	5.6
	Average depth when below maintenance level (ft)	0.28	0.37	0.15
	Estimated 31-year total demand-not-met (1000 acre-ft)	11.6	21.3	8.0
	Average Lake Okeechobee water supply delivery to keep maintenance level (1000 acre-ft/yr)	0.738	1.076	0.638

+ : two-cell average; * : two-cell weighted average; # : two-cell total

Summary

As part of the overall Everglades restoration project, updated regional hydrological modeling simulations were performed by the Hydrologic Systems Modeling Division. The objectives of the simulations were: 1) to establish a new base simulation which incorporates the data sets used in the C-139 Rulemaking process; 2) to refine the operating criteria for STA-5 and STA-6; 3) to create a future case scenario using the new base simulation plus structural and operating rules as proposed by the Comprehensive Everglades Restoration Plan and up-to-date information for the WPA project and EAA reservoirs. This memorandum documents the differences in model output and performance of the previous base (BASERR1), new base (BASERR2R) and future base with project (2050wPROJ) simulations. Changes in modeling input and assumptions were referenced in order to explain differences in model output and performance.

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c: K. Tarboton, HSM, WSD
R. Novoa, HSM, WSD